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Governing the transition to natural gas in Mediteranean Metropolis: The case of Cairo, Istanbul and Sfax (Tunisia)

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HIGHLIGHTS

- Considers the governance of natural gas networks in emerging cities.
- Adopts a geographical approach looking at interactions between natural gas infrastructure and urban space.
- Switch to natural gas linked to financial purpose (subsidy cuts) more than concern for climate change.
- Switch to natural gas shaped by policies governing other urban energy forms.
- Urban politics and issues of affordability impact the governance of natural gas transition.

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ABSTRACT

Recent scholarship on urban energy governance has focused on low carbon energy strategies seen as a response to climate change and energy pressure threats. But such approaches tend to overlook the situations of cities from the Global South and emerging countries concerned with strong energy demand growth. The development of urban natural gas networks is an understudied response to such a challenge. Focusing on three cities, Istanbul, Cairo and Sfax (Tunisia), the article analyses the factors and the governance of these energy transitions. It uses a geographical approach to such processes that highlight the mutual influence of the territory in its material and political dimensions and of the policy goals and tools in the implementation. The development of urban gas networks rests upon the proximity of gas deposits. It is determined by metropolitan strategies for economic development as well as by programs aiming to cut energy subsidies. Though urban gas networks have a strong potential for restructuring the physical and social landscapes in cities, the dominant commercial approach taken by energy utilities and morphological constraints in the urban fabric limit their universalization. Natural gas is part of a mix of energies at the urban level and often competes with other energy forms, specifically renewables (like solar water heaters). Lastly, the development of urban natural gas networks sparks heated politics in relation to unfulfilled energy demand and affordability.

1. Introduction

In the context of climate change, cities are seen by numerous observers and actors at the international, national or local level as key institutions and places in order to design and implement energy transition strategies aiming to promote low carbon energy policies. Available academic works on these issues analyze the determinants and the tools of such policies. They highlight the possibilities opened by new technologies, the advent of alternative sources of energy and political changes that enable urban actors, with various degrees of success, to gain agency to deal with the nexus city/climate change and, hence, energy (Hodson and Marvin, 2010; Coutard and Rutherford, 2010; H. Bulkeley et al., 2010; H.A. Bulkeley et al., 2010). The available scholarship tends to focus largely on northern and large cities, where such energy transitions begin to materialise. Several academics contend that further studies are needed to understand energy issues and prospects for change in cities from the Global South (Hodson and Marvin, 2010; H. Bulkeley et al., 2010; H.A. Bulkeley et al., 2010). Recent scholarship underscore that such cities follow very different paths compared to what is observed in the North. Specifically, because climate change does not seem to be the

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priority there, low carbon technologies are not the main focus of energy policies in such cities and issues of access, shortages and affordability dominate the agendas (Jaglin and Verdeil, 2013).

The literature on energy transition has well documented the electrification of rural areas and its governance (for instance: Davis (1998), Heuraux (2010), Murphy (2001), Rehman et al. (2010)). But until recently, apart a few studies, urban energy transitions in developing and emerging countries have remained overlooked by research, though one can assume that the classic scenarios, as well documented by historians (Smil, 2010), do play out – and not the quest for low carbon energy. They imply a move away from so-called traditional forms of energy (notably biomass and its by-products such as charcoal) towards modern types of energy (electricity, liquefied petroleum gas [LPG] in cylinders, petrol for automobiles) as well as different types of so-called transition energies (kerosene, diesel, fossil coal, etc.) (Barnes et al., 2005). Urbanization is a driving factor in these transitions too, although other factors such as income level, the kinds of resources available nearby and public (fiscal, rate or infrastructure) policies also play a role and make the path to such transitions substantially more complex. Energy transition is not defined only by shifts in the fuel mix but also by customers' practices and urban change. Among these, electrification and electricity issues in ordinary cities of the Global South are the topics that have attracted most of the interest (for instance: (McDonald, 2008; Jaglin, 2014; Verdeil, 2014b; Silver, 2013b).

Other urban energy technologies remain under documented, notably natural gas supplied through networks. There have been a few studies analyzing the rise of this energy form in several cities in emerging countries like Brazil (Kamimura et al., 2006), Turkey (Özcan et al., 2013) and above all, China (Chen et al., 2013, 2014; Yu et al., 2014). Substituting natural gas to coal appears as a good way to reduce energy consumption and cost, as well as greenhouse gas emissions. At the local level, developing natural gas network also takes part in mitigating pollution policies, which is a major concern in China (Mao et al., 2005). But these studies that mostly stem from economics or energy technology fail to address "the interaction between urban change and the transformation of energy systems – urban energy transition in short" (Rutherford and Coutard, 2014). This article claims to analyze the transition to urban natural gas networks from a geographical point of view, by analyzing three Mediterranean metropolises where urban natural gas networks have been built in the past 20 years: Istanbul in Turkey, Cairo in Egypt and Sfax in Tunisia. It shows how the urban social and political contexts and local dynamics shape the distinctive features of these energy transitions. Therefore, energy governance has to find ways to integrate urban actors and their interests, though it is difficult to identify convergent characteristics given the inherent diversity of local situations.

2. Materials and analytical framework

Before presenting the materials used in the study, this section displays the analytical framework elaborated to compare the ways though which energy issues and specifically the development of natural gas networks have become urban issues in the three cities studied, and the energy governance it entails. To do so, this framework connects energy issues and spatiality. A recent synthesis has applied a series of geographical concepts that allow us to grasp "how energy transitions are spatially-constituted" (Bridge et al., 2013, 339). Though this study was meant for understanding low carbon energy transition, it provides a framework that can be easily applied to other energy changes. The relevant concepts for the purpose of this article are location, territoriality, spatial differentiation, uneven development and spatial embeddedness. It is also necessary to look at the contributions made by other scholars at the crossroads of environmental studies, socio-technical studies and urban studies. Their research discusses the governance of climate change and energy policies and emphasizes the need to think about the political dimensions and power relations between social groups and actors within the analyses of energy transition (Hodson and Marvin, 2010; H.A. Bulkeley et al., 2010). This approach is best expressed by Rutherford and Coutard's recent call for "studying the co-production of energy systems in transition and systemic urban change, the contested and political processes involved and their uneven socio-spatial outcomes across diverse global urban contexts" (Rutherford and Coutard, 2014, 1359). Recently, the emphasis on energy justice has refined the framework for analyzing the socially differentiated participation in such processes and their uneven outputs (Bickerstaff et al., 2013). This article analyses the implementation of gas networks in the three cities according to five entry points which are defined by combining the issues and related analytic criteria underscored in this research.

(a) The first focuses on location, understood as relational proximity, which notably allows one to identify one element of an energy system in relation to the others: e.g., the city as a consumption hub in terms of energy resources or transport channels for such energy (Bridge et al., 2013). Energy transition strategies depend upon new pressures on resources and energy supply – in other words, in our study, access to gas resources. This implies analyzing the proximity of deposits and gas pipelines. The discovery and extraction of new Mediterranean gas deposits over the past 20 years and the geopolitics of pipelines between Asia and Europe thus have modified cities' access to this energy source.

(b) The second point is the connection between energy transitions and the metropolitan project as defined and advanced by metropolitan coalitions of elites. This analysis refers to the concept of territoriality (Bridge et al., 2013) e.g. "how social and political powers are organized and exercised over space". It is therefore needed to identify the political projects (and their initiators) associated with such technological changes (in our study, the supply of gas). In their work, Hodson and Marvin (2010) argue that urban energy policies are part of a broader set of strategies connected to both increased pressure on resources and, thus, to a need to secure cities' supplies, but also to a reshaping of the respective roles of States and world cities in neo-liberal economies. The latter have a direct interest in implementing new policies – including energy transition – in order to secure their economic footing and, thus, improve their productivity and diversify their markets. Therefore, it is necessary to identify the actors that create new interest groups at the urban level (which unite the entrepreneurial classes and political-administrative elites), as well as their visions of the future and how the development of urban gas networks is becoming a part of them.

(c) The third point of the analysis focuses on the connections between the implementation of gas networks and urban reconfiguration in terms of both urban materiality and urban cohesion. This involves analyzing the networks' spatial extension in each city, users' access to the service and the uses that form around these networks. Through these criteria, the research addresses the universalization of service in each city and the barriers to it. This raises the issue of energy justice, as the result of both spatial differentiation and unequal development (to use Bridge et al.'s (2013) concepts), combined with the claims made by some stakeholders against the results of these policies in the name of fairness (Eames and Hunt, 2013, 48).

(d) The fourth point analyses the articulation between the development of gas networks and other energy measures and policies in terms of competition versus complementarity. The analysis refers here to the notion of "spatial embeddedness and path dependency" (as connected to energy issues by Bridge et al. (2013)), that is, to the slowing effects that past infrastructure investments and "place-based cultures of consumption" (p.338) can have on energy transitions. This involves thinking about the connections between the new energy service (the gas network) and the existing set-up in material as well as social, economic and cultural terms (the previously used energy resources and services, like bottled gas, charcoal or solar water heaters that are implemented during the same period as natural gas networks). It further means thinking about transitions as experienced at different speeds, and about relationships between different energy types and services which are not limited to succession/substitution but also involve co-existence, which implies competition as well as complementarity.

(e) The final point in the analysis focuses on the politics of energy transitions and more specifically on conflict and opposition to measures defining access to and the use of gas. The research draws here from studies that addressed the need to take into account reactions to and ways in which new technologies have been appropriated by city dwellers, users or builders. Indeed, their ability to protest against or circumvent energy transition policy measures thanks to unexpected practices or material disruption can be the causes of uncertainty or of unforeseen changes (Castán Broto and Bulkeley, 2013; H. Bulkeley et al., 2010; Cupples, 2011). Just like problems related to defining instruments and setting measures for new technological facilities (e.g., subsidies or fiscal incentives), it may lead to results different from those initially anticipated. In this sense, energy transitions must be seen as "unruly". To what extent can these observations be applied to the customers' reactions to the implementation of natural gas networks?

The following section draw on the results obtained three long-term fieldwork surveys in the different cities, coupled with shorter stays. For two of the cases, fieldwork was conducted over a 4-month period; for the third case (Cairo), fieldwork lasted a year. The research draws on three types of sources: an in-depth look at the technical literature, notably from network operators, as well as available cartographical and statistical data; the media, particularly the available press reviews; and interviews conducted with public administration staff and operators (on average 20 interviews in each city) as well as with inhabitants during fieldwork visits (10–20 small qualitative semi-structured interviews per city, focusing on access, technical difficulties, quality of service, affordability issues). The operation on the fieldwork was globally structured according to the following analytical framework.[1]

3. Results: the development of gas networks in Cairo, Istanbul and Sfax

3.1. Contextualizing Cairo, Istanbul and Sfax: emerging and energy-dependent cities

Before analyzing the results, this section provides some general features about the three case cities, which differ in size but nonetheless share the characteristics of emerging cities. Four factors define emerging economies: being in a middle-income country; having a "catch-up" economic impetus resulting in a GDP growth rate that is clearly superior to old industrialized countries; institutional and structural economic changes embodied by direct foreign investment in industry and services, and an increase in trade; and finally strong growth potential (compared to advanced economy countries) (Vercueil, 2011). Table 1 – which lists countries since data for the cities themselves are not available – confirms these criteria.

Table 1
Country development indicators.
Source: World Bank, UN Data

Country	Income per capita (PPP) ($)	Income group	Annual GDP growth (ave. 1990–2011) (%)	Foreign direct investment (2010) (M US $)	KWh per capita 2011	KWh per capita 2001
Egypt	6723	Lower-middle income	2.8	6711	1743	1074
Turkey	18,348	Upper-middle income	2.4	9036	2709	1615
Tunisia	9795	Upper-middle income	3.3	1334	1297	1048

If we look at cities more specifically, the emerging metropolis has other additional characteristics worth taking into account (Lorrain, 2014).

According to Table 2, their demographic growth is striking. Combined with the recent decoupling between demographic growth and (even more rapid) spatial expansion, it has led to the rise of immense and contrasted agglomerations. Istanbul experienced booming growth between the 1960s and 1980s; this rate has now slowed somewhat but has nonetheless resulted in more than a doubling of the city in the past 30 years in a perimeter that is constantly being redefined. Cairo has experienced equally strong growth. Its density has remained relatively high, but since 2000, the urban perimeter has tripled with the construction of huge gated communities in the desert. Sfax, Tunisia's second largest city, has also experienced strong growth (in the context of a more marked slow-down in demographic growth in Tunisia).

There are very stark differences in the standard of living and lifestyle of these quickly expanding populations. The prevalence of informal or unregulated urbanization is very strong and underscores how hard it can be to find decent housing. This is a product of massive poverty but also of problems regulating real-estate markets.[2] In Cairo, it is estimated that 62% of households lived in informal zones in 2006 (Sims, 2010); in Istanbul, this involved 60% of households in 2008 (Pérouse, 2010, 251), but this percentage declined significantly following government changes to housing policy; in Sfax, informal settlements represented at least 40% of housing in 2003 (Bennasr, 2003). This situation is often aggravated by limited access to essential urban services (notably water, waste facilities, transportation and energy). However, regularization policies are much more integrative with respect to urban infrastructure in Tunisia than in Egypt (Chabbi, 2012; Sims, 2010).

Despite this social inequality and unequal access to network services more particularly, the three cities have all experienced a strong rise in the demand for energy (Özcan et al., 2013; Brand and Zingerle, 2011; Suding, 2011). Between 2001 and 2011, at the

[1] For more detailed information, refer to the Master's theses, available online, that provide a first analysis of the gathered data (Arik, 2011; Bolzon, 2012; Markoum, 2011).

[2] Informality is obviously defined differently in each legal context, but the shared common denominator is the construction of housing outside of official procedural channels at the time of construction.

Table 2
City development features.

City	Population in 2010	Population in 1980	Density in 2010 (inhab./km²)	Recent changes in density
Istanbul	12,800,000[a] (2008)	4,742,000[a]	2285[a]	Urban sprawl encroaching on natural areas
Cairo	15,688,000[b]	7,652,000[b]	1307[b]	Desert development with low density are twice as large as built up areas
Sfax	525,000[b]	301,680[b]	183[b]	Very marked urban sprawl into surrounding agricultural areas

[a] DIE (Turkish Statistical Institute), in Pérouse (2010).
[b] e-Geopolis database ⟨http://www.e-geopolis.eu/menapolis⟩.

national level, per capita power consumption increased, this increase reaching 23%, 62% and 68% in Tunisia and Egypt and Turkey respectively.[3] This reflects progress made in electrical distribution and an increase in new household-appliances use (e.g., TV, refrigerators, etc.), particularly amongst working and middle class populations. Other uses such as the steep increase in air-conditioning use (hot and cold) are signs that new practices and representations of physical comfort are spreading. Overall, these urban centers are experiencing major changes in their energy systems (Verdeil, 2014b), among which the development of a gas network is one under studied component.

Another important point to consider is the institutional situation in these emerging cities. All of the cities are, to varying degrees, under State control. Nowhere is this stronger than in Egypt where there are no municipal institutions. The way jurisdiction has been divided in the other two cities means that municipal institutions have limited or even very weak power in Turkey and Tunisia (Massicard and Bayraktar, 2012; Turki and Verdeil, 2014). Moreover, as in many emerging cities (Lorrain, 2014) urban growth has made institutional unity impossible: Cairo has three distinct governorates, and the agglomeration of Sfax is comprised of 7 municipalities. Only in Istanbul can one observe the emergence of a single metropolitan authority, which is nonetheless heavily controlled by the State (Pérouse, 2010). However, in Cairo and Istanbul, urban services like water, electricity or transportation are managed by metropolitan or regional utilities or administrations, while it is the case in Sfax only for transportation.

In terms of their economies, the three metropolises are very industrialized. Istanbul and Cairo are their country's main industrial production hub, although both are facing industrial dispersion and a shift towards specialization in services (Denis and Vignal, 2002; Pérouse, 2010). As for Sfax, it is the largest industrial city in the country (Bennasr, 2005). In all three cases, this industrialization is tied not only to local markets, but is also directly connected to each country's involvement in the globalization of trade.

3.2. Energy diversification and the accessibility of gas resources

The extremely rapid increase in demand for energy mentioned above has occurred alongside the soaring prices (particularly in the past 15 years) of international hydrocarbon – especially oil-products. This has created a desire to diversify energy sources, which has in turn cashed-in on recent developments in the exploitation of natural gas. Indeed, the implementation of gas networks in the three cities would never have been fathomable or possible without a turn towards gas in energy policies. This turn can be explained by the exploitation of newly discovered natural gas deposits in the surrounding environment and/or the passage of a gas pipeline across the country transporting gas towards other markets, both of them leading to the emergence of uses for natural gas (industrial and electric, as well as domestic), starting in the 1980s.

Egypt is ranked third in Africa in terms of its known gas reserves. These reserves have mostly been exploited since the 1980s, notably for electricity production, industrial use and, more recently, for residential consumption and as automobile fuel. Although some of the gas is exported (notably to Israel, which has further fueled controversy since the 2011 revolution), its local use has also flourished.

Tunisia also extracts natural gas from deposits in the south of the country and off the coast near Sfax through State-owned companies and, since the 2000s, multinational corporations. An Algerian pipeline also crosses Tunisia on its way to Italy and European markets (Fig. 1). Tunisia is allowed a free quota on the amounts transported as a transit fare. This available gas has spurred policy aimed at replacing oil with gas and its by-products for electricity production, industry, residential use and, more recently, transportation. In 2010, natural gas accounted for 53% of the primary energy consumed in the country.

The Turkish case is different since the country does not produce natural gas. Turkey has, however, become a veritable energy hub, with several gas pipelines from Central Asia, Russia, the Caucasus and Iran transiting through the country since the late 1980s (Chuvin, 2008). One of these pipelines crosses the Dardanelles towards Greece and other projects are planned, notably the Trans Anatolian destined more specifically for the exportation to Europe of Azeri gas from the Caspian Sea. The troubled geopolitics surrounding these projects makes them difficult to follow, particularly given that the economic crisis has affected anticipated need and, thus, their forecasted profitability. Overall through, this has not affected the important role played by Turkey in supplying Europe. Alongside the transportation of gas to Europe, Turkey has also diversified its gas use, notably for electricity, industry and in the residential sector. Istanbul was one of the first cities affected by this.

The greater availability of gas is specific to a certain number of countries and cities, and has encouraged a reshaping of broad energy policies. But other factors are more influential.

3.3. Actors and justifications behind the implementation of urban gas networks

Looking at the public policy contexts behind the launching of gas networks and at the coalitions of actors that justify and impose them is one way to identify the diversity of visions and how they are connected to urban issues.

In Istanbul, the start of the gas network in 1986 corresponded with a newfound availability of gas, when a pipeline from the Soviet Union reached the city. But the main driver behind its implementation was the massive air pollution in the city, whose root cause was the widespread use of coal at the time (Arik, 2013). This pollution was the subject of intense local debate in the early 1990s, but acceleration of the gas network's construction also hinged on two events in urban politics: the emergence of the Islamist Refah party (now the AKP), which has dominated

[3] Source: World Bank. Again, city level figures are unavailable because energy utilities' operating perimeters usually surpass urban borders. A strong national increase therefore reflects not only urban changes but also rural electrification.

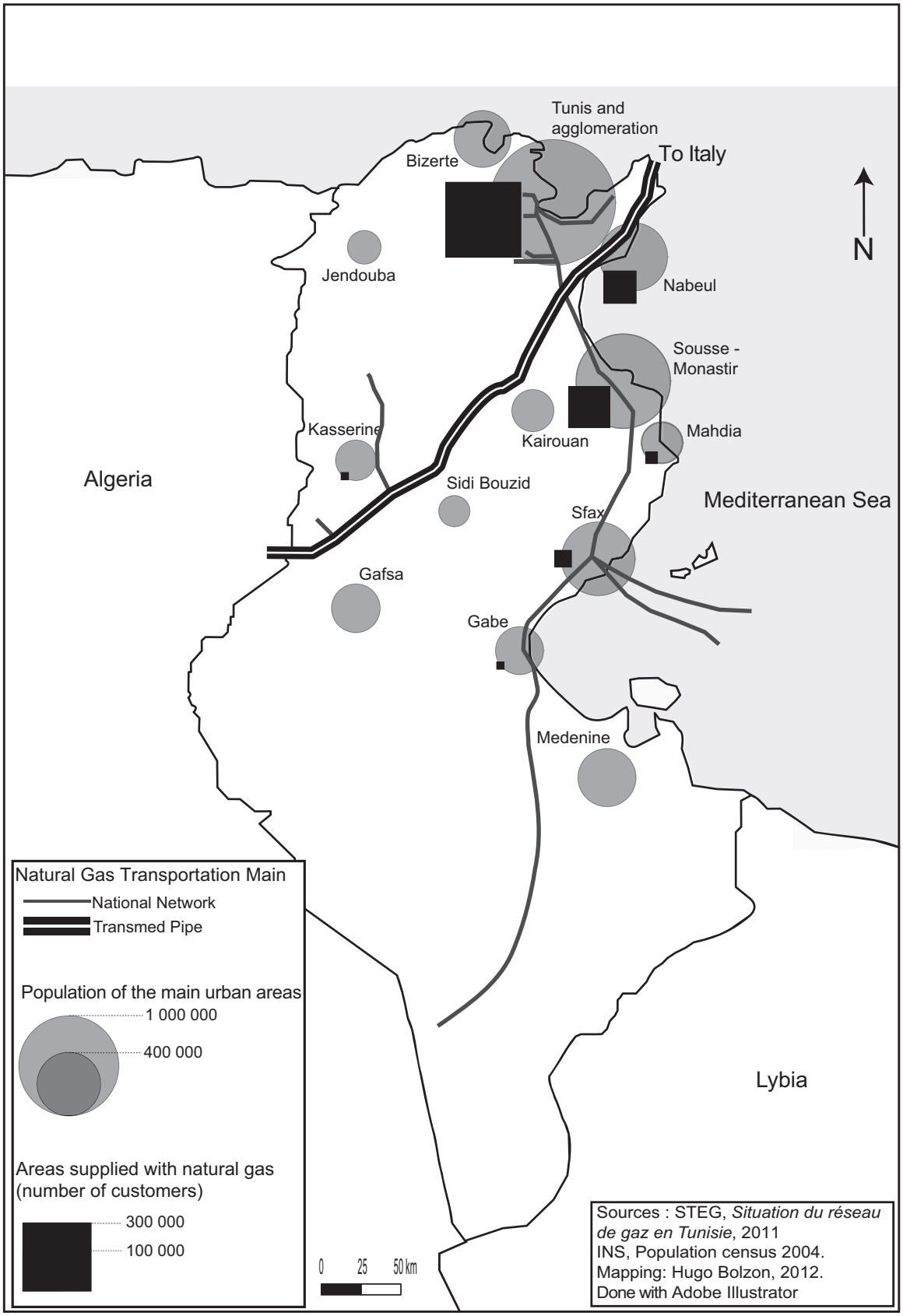

Fig. 1. Tunisia natural gas network and main supplied areas.

local political life since the 1990s and, under its supervision, a turn towards the internationalization of the metropolis which resulted in an accelerated modernization of the city's infrastructure and urban space. It was the municipality, dominated by the Islamists, that was the main vector of this environmental modernization of Istanbul, which was part of a larger

modernization project. Two municipal agencies were set up and played a key role in the gas project: IGDAŞ, the municipal gas utility, and UGETAM,[4] an international research centre IGDAS and the municipality created in 1999 to adapt the technical norms to the local market and train the staff. Neo-liberal reforms to the gas market occurred only much later and did not play a role in the construction of this market. It is also worth noting that based on its pioneering experience the municipality of Istanbul has helped spread the idea of using urban gas network technology to other cities in the country.

In Cairo, the construction of urban gas networks was much less tied to a desire to address a local public problem. It was rather part of a national policy to curtail the amount of subsidies to the energy sector in the context of structural adjustment in the late 1980s (Markoum and Verdeil, 2013). In a context of rising oil prices and severe fiscal crisis, the development of natural gas was presented to Egyptian authorities by the World Bank as a source of budgetary savings. Available locally, natural gas has indeed replaced imports, particularly the LPG in cylinders widely used by city dwellers. The government subsidized LPG at a rate of 90% of its real cost, as Egyptians are very sensitive to price increases of this commodity essential for cooking and heating, specifically in cities. The development of urban gas was thus a national program created in response to pressure from international donor agencies. Metropolitan actors were in no way involved in the project's elaboration, whose implementation was then committed to Town Gas, the affiliate of Egyptian Gas National Holding (EGAS), with no link with local authorities. There is, however, a similarity between the development of this network and the development of other urban modernization programs which, like in Istanbul, have aimed to improve the international image of the Egyptian capital, like waste collection (Florin and Debout, 2011). But while the latter has been delegated by the public authorities to private firms, this is not the case for gas, which is not entrusted to the private sector but rather to regional public utilities for the distribution of gas.

In Sfax, the main motivation behind the promotion of gas is similar to the Egyptian case: it is driven by macro-economic reasoning aiming at reducing energy subsidies, particularly for imported LPG which is very sensitive to fluctuations in international prices. The development of a gas network for residential households has been promoted in most large cities since the 1980s and in Sfax since 2002. This policy was implemented by a national State-owned company, the Société tunisienne d'électricité et de gaz (STEG – the Tunisian Gas and Electricity Company). In contrast to Istanbul, no local environmental or energy problem justifies the discourse of urban modernization. Local authorities, and particularly the municipality, were in no way involved in this policy, nor in any other infrastructure equipment policies (e.g., water, electricity), as these are the sole domain of the State and public sector companies. And yet, the main target of authorities in the policy of using natural gas as a substitution has always been industry customers since they are the only ones that can guarantee a return on the investments made. It was in this context that Sfax, the country's largest industrial city, was a prime target as soon as the new deposits in the Gulf of Gabes were exploited.

The justifications and governance underpinning the development of natural gas in each city (and the actors involved) are thus quite different. They are closely connected to the city and its problems in the case of Istanbul, where the municipality is an important actor. However, they are above all in the hands of the State and World Bank in the Egyptian case and in the hands of the State in the Tunisian case. In both the latter cases, the purely urban dimensions are quite secondary. But, as we will see next, there is a quite specific urban component to the ways in which these networks have been rolled out and accessed by local populations.

3.4. The expansion of gas networks and the material and social reshaping of the city

The development of networks and infrastructure for urban services has historically been a vector for social integration, particularly in Western cities. The universalization of networks and the economies of scale they provide, combined with direct or indirect public control (e.g., delegation of services, setting rates, etc.), were, in the case of water, electricity and transportation, a strong integration factor in the building of welfare states. And yet, have the policies at work in the neo-liberal context of the past 20 years not altered the meaning behind the development of new types of infrastructure such as natural gas networks in cities in emerging countries? In the three cases studied, the inclusive nature of the networks has been stifled or even countered by, on the one hand, the financial conditions required to access them, and, on the other hand, by the nature of urban morphology.

In Istanbul, there is a strong mindset of universalization. The network's extension has been conducted in a very voluntary manner by IGDAŞ, the municipal gas company. Over a 20 years period, the network built 11,000 km of piping, and 97% of urbanized territory in the metropolitan municipality is now covered, supplying nearly 5 million residential customers (Fig. 2). And yet, this universalization does not involve the sole use of gas; many users still use coal for some purposes (notably in the *soba*, the traditional heating stove). Some people do not use gas even though their home is connected to the mains. Indeed, the cost of equipping a home, as well as the price of the gas consumed, is not at all subsidized. Such expenses weigh heavily on the budgets of less wealthy households. Turkey's neo-liberal turn is reflected in the IGDAŞ rate policy, which is based on full cost recovery. This has in turn led to the paradoxical universalization of a service that is not used (Arik, 2013).

Cairo is similar to Istanbul, but the network's implementation is less developed. In 2006, roughly 1.5 million households were equipped; the program launched that same year aimed to increase this number to 2 million, which would represent about 55% of households.[5] Two factors have dissuaded users from getting connected: first, its relatively high cost, and secondly, the cost of interior equipment, despite credit opportunities. Despite the advantages, both financially and in terms of comfort, once the installation is complete, many households cannot afford the financial burden, particularly those with low or irregular income. Paradoxically, while these costs are no longer open to government subsidies, the central parts of Cairo that were the first to benefit from the gas network received government subsidies – and their inhabitants are, for the most part, financially quite well off. A second factor has also hindered the development of the gas network: safety concerns have made it impossible to connect some of the informal districts, either due to the poor state of their buildings or to the density and lack of space in their narrow streets (Fig. 3). As such, the network's development has excluded some of the poorest people and urban sectors; far from being a vector for integration, the network has actually exacerbated existing inequalities.

The case of Sfax is quite similar to Cairo, with one notable difference: the gas connection program is more recent (2002) and

[4] IGDAŞ=Istanbul Gaz Dağıtım Sanayı ve Ticaret A.Ş; UGETAM=Uluslararası Gaz Eğıtım Teknoloji ve Araştırma Merkezi.

[5] Personal calculation based on an estimated household size in Cairo of about 4.5 and the population for the year 2010. The real advancement of the program, given the problem it faced, remains under this level.

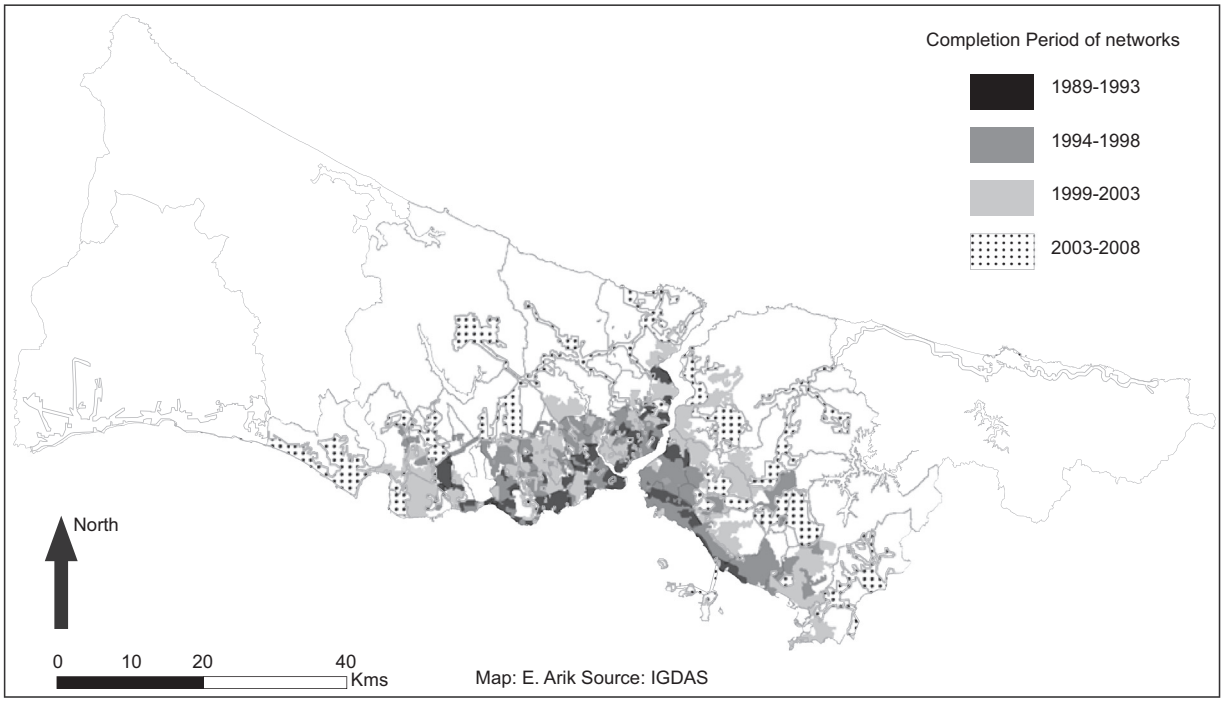

Fig. 2. The extension of the urban network of natural gas in Istanbul.

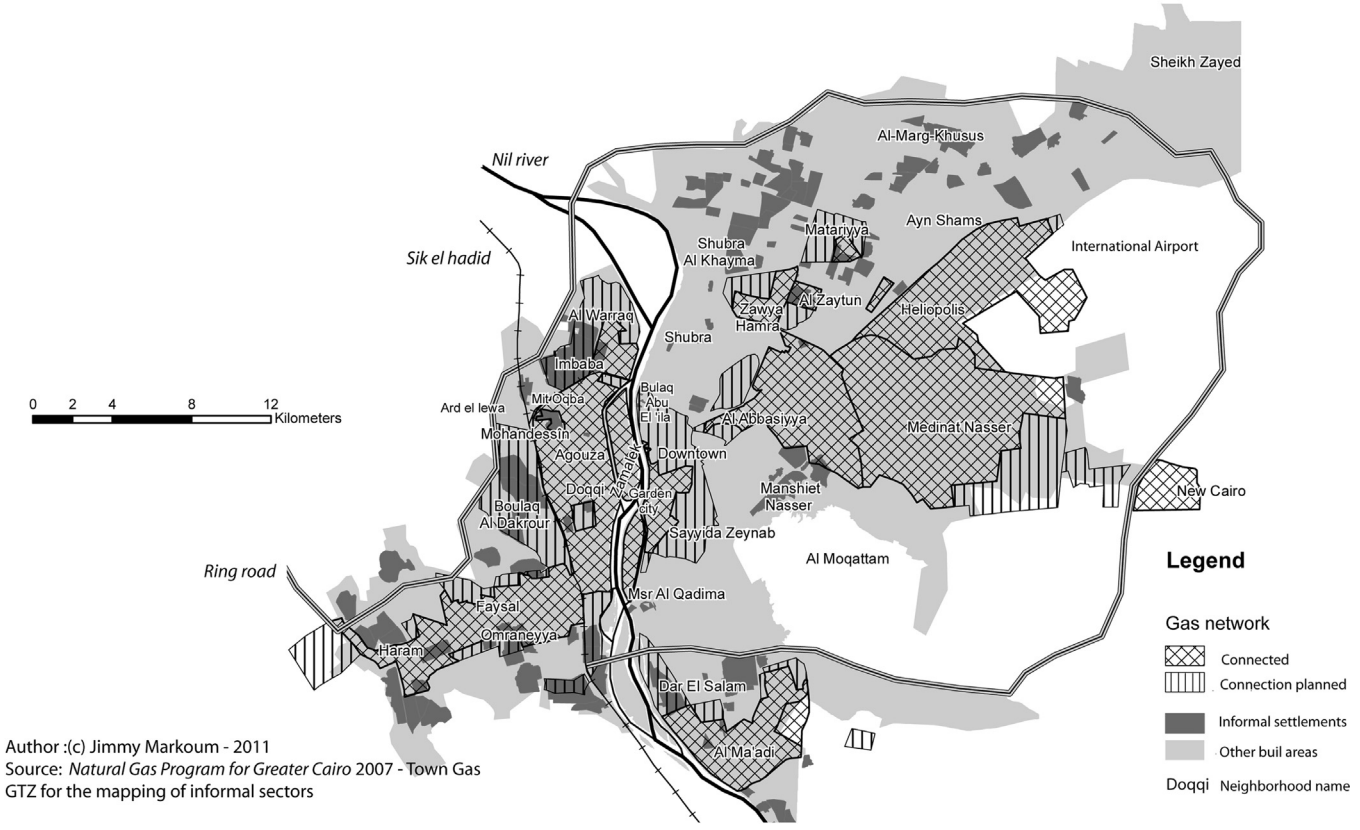

Fig. 3. The Natural Gas Program for Cairo and the informal settlements.

has yet to meet its targets, with less than 20% of households connected (Bolzon et al., 2013). Here too, the cost of getting connected and of equipping homes is a dissuasive factor for many poor households, even though the government has handed out large subsidies since 2002 to help with the cost of getting connected to the network. Among other things, and as in Istanbul, many of the users connected to the network (over half) do not use it since they have not yet equipped their homes with the necessary interior installations, essentially due to cost. The impact of urban morphology is however different in Sfax than in Cairo: the city is

very dispersed over a flat area, with numerous low density "garden" districts (*jneïn*) that do not meet the operator's profitability criteria for a connection. Even for those that would be eligible, the length of the copper pipes needed for the interior installations make the scenario quite unattractive.

To varying degrees, in all three cases, the development of a natural gas network has not resulted in the universalization of the service despite the operators' ambitions. This is in part due to financial reasons. Apart from in the Tunisian case, access to the service is indeed not subsidized, nor is the cost of the interior installations required, which have to be paid for by households and constitute a large share of the investment. Further, certain morphological limitations combined with profitability and safety criteria mean that one part of the urban fabric is excluded from the network. Given this, gas network services have not helped reduce socio-spatial inequality and have even actually accentuated it in Istanbul and Cairo. The transition to this new energy service is thus incomplete. This is also due to the interplay between different energy systems.

3.5. Urban gas networks and other energy options

The move to a new energy network has not occurred uniformly, excluding a large portion of the population. But, unlike water or electricity networks, which are truly essential services, the lack of or inaccessibility to a natural gas networks can be tempered by other systems, such as bottled gas or coal. What is striking in this context is the interconnection and co-existence of different types of access to energy: the modern industrial-type network coexists with other types of energy, notably individual ones which are sometimes informal or traditional, as well as occasionally renewable energy systems or energy-saving systems such as solar water heaters (SWHs). These different types of access to energy may be complementary or competing.

Thus, as mentioned above, coal and wood, as well as LPG cylinders are still alternatives for city dwellers who do not wish or cannot be connected to the network in Istanbul. In Cairo and Sfax, too, LPG cylinders are an obvious alternative for city dwellers. Another practice also exists in Sfax: a non-negligible portion of households (nearly 10%) has chosen to install a solar water heater, strongly encouraged by an energy-saving program run by the Tunisian government. These households have therefore chosen not to install gas, which is really only advantageous for users with central heating (thus requiring greater interior investment). Paradoxically, both programs were designed to save energy but have proven to be competitors and stifle each other. This contradiction does not appear to have been detected by Tunisian authorities, perhaps because it is an issue only in Sfax where gas was implemented later and where SWHs were adopted earlier than elsewhere (Bolzon et al., 2013).

In any case, city dwellers in all three cases weigh the pros and cons between energy that is more comfortable to use and sometimes less expensive to consume, and access costs that conversely can be quite discouraging. These services can be both complementary (city-dwellers in districts not supplied by gas can buy LPG cylinders or use coal) or competing, when city-dwellers make decisions based on the cost of coal or LPG versus networked gas. In making such decisions, most city-dwellers show they are not locked-in to a given energy system. Most use is still quite basic – the complex household appliances that could reshape domestic life remain rare – and it has not stopped people from going back and forth between different domestic energy options: most are poor households which are not well equipped and which have not (yet?) reorganized their living space around a single energy option. In this sense, we are still very much in the period of network infancy described by Dominique Lorrain (Lorrain, 2001) despite the (albeit unequal) progress made in the universalization of gas network services. In other words, the systems related to the different energy transitions simultaneously underway are not yet sufficiently "embedded" to create a path dependency effect.

3.6. Transition politics of networked gas

The development of gas networks in the three cities has become a political issue that had overflowed beyond the institutional political sphere to settle onto the streets through demonstrations, protests and the advocating of practices that contradict or circumvent network development.

In Istanbul, the rise of gas price has regularly sparked demonstrations of discontent, nevertheless unable to reverse such decisions. Other forms of politicization are more subtle. During election campaigns, local representatives of the Islamist party and the associations connected to the party's charity activities distribute free coal to poor people. Thus, in the name of electoral populism, the local practices of party representatives go against national and municipal policies to promote energy transition towards gas. These practices then confirm citizens in their reticence towards gas and help explain why they prefer not to use this fuel or equip their homes even when gas is readily available (Arik, 2013).

In Cairo, the research highlighted the role of recurring shortages of LPG cylinders, notably in winter, which have fueled very strong demands – before and after the fall of Mubarak. Protesters are particularly critical of the fact that these shortages cause price increases and work to the advantage of a mafia thriving in the shadows of both the former regime and in its aftermath. Discontent is also fueled by the fact that part of Egypt's natural gas is exported, notably to Israel (and also to Jordan). It was revealed that the export contract bore the trace of corruption in favor of someone with close ties to Mubarak.[6] Given this, protesters became critical of the non-availability of natural gas for Egyptians – in a context in which many, particularly the poorest, cannot afford it (not to mention the technical limitations). Combined with recent problems in the distribution of electricity, these shortages have fueled dissatisfaction towards the Muslim Brotherhood and were one reason behind the ousting of President Morsi in July 2013. Further, several observers have noted that one of the first measures taken by the military government was to improve the power supply – fueling suspicions that the network's deterioration was, in part, fictitious.[7]

Energy issues have also been politicized in Tunisia, particularly because of price hikes in electricity and gas (which are managed by the same company). While STEG policy from 2005 to 2010 tended to become cost-reflective in order to reduce the amount of energy subsidies, the post-revolutionary governments have been careful not to pursue this policy or at least be very cautious (with a first, small increase in September 2012, followed by another in the spring of 2013) (Bennasr and Verdeil, 2014). The issue of LPG has also been politicized: in December 2011, an extreme cold snap led to problems with the distribution of LPG, particularly in the mountain regions. Given this, some consumers decided to turn to the gas network in Sfax and other equipped cities. This crisis especially underscored the dependence on LPG. Aside from the bad weather, one reason for the supply problem was due to sit-ins barring access to factories by unemployed people demanding jobs

[6] "Egypt jail terms over Israel deal", *in BBC News*, June 28 2012 ⟨http://www.bbc.com/news/world-middle-east-18623625⟩.

[7] Hubbard, Ben, Kirkpatrick, David D., 2013. "Sudden Improvements in Egypt Suggest a Campaign to Undermine Morsi". *The New York Times*, July 10, sect. World/Middle East. ⟨http://www.nytimes.com/2013/07/11/world/middleeast/improvements-in-egypt-suggest-a-campaign-that-undermined-morsi.html⟩.

in the government-run LPG bottling facilities.[8] Hence, this energy is not only very costly for the government; it is also a source of public sector jobs which may further increase the cost of subsidies. At the same time, the crisis and dependency on LPG underscore how difficult it would be to raise the price of this energy despite the fact that it would be a good way for the government to encourage the transition to a gas network. Indeed, since the countryside and numerous municipalities do not for the time being have access to the gas network, any increase in the price of bottled fuel would be seen as a betrayal (and increasing the price solely in cities would simply lead to black market trafficking).

The way these energy issues have been politicized actually underscores the connections between one type of energy and the others available on the market, revealing that it is not possible to isolate one energy policy from the rest since each one is shaped by the others. The (at times violent) demonstrations they generate are a sensitive issue for the regimes, illustrating the power of urban crowds, both electorally and in the occupation of public space, as the Arab Spring mobilizations have demonstrated (Verdeil, 2014b). Hence, this pressure has pushed governments to maintain the subsidies that they claim elsewhere to want to reduce, thus hindering officially promoted energy transitions. It is obvious that the way these transitions are conducted does not depend solely on the right dose of financial incentive (subsidies, regulatory incentives, etc.), but also on a political ferment that is very sensitive to the energy used, its cost and availability. Essential to urban life, energy can become a right for which citizens are prepared to fight.

4. Discussion

The results exposed in the previous section are presented according to issues that derive from a so-to-say sequential description of natural gas projects implementation. This presents the shortcoming of hiding dynamics and links existing between these several layers of the analysis. For instance it does not acknowledge the interplay of elite-driven decision-making regarding the energy transition and adaptations and transformations of such policies because of their perception and appropriation by the citizens. This presentation also obscures the co-constitution of energy transition policies and the territorial formation (both in political and material terms). We discuss these issues now.

Let us start with the fact that the switch to natural gas currently reveals a weak concern, if any, for social cohesion and energy justice. However, the emergence of an energy urban issue on the street has led to deep transformations of energy transition governance and results in changes of the scope and design of these policies. This is why energy transition governance cannot be understood as elite-led.

At a first glance, this popular politics might appear as more reactive to the energy transition policy than formative. This is especially the case with protests against price hikes. The government fear of the popular anger can be a major curb against energy transition if, for instance, government renounce to tariff increases intended to push customers toward new energy services. In this perspective, the people resist the energy transition and can stall or even derail it.

But other characteristics of popular mobilizations about energy issues have transformed the energy agenda. Many protests, specifically in Cairo and Istanbul, have targeted power cuts, shortages of gas bottle or the absence of modern energy service in certain neighborhoods. For them, the right to the city includes a right to electricity as a fuel of urban life (Verdeil, 2014a, 2014b). In so doing, they take seriously the promise that energy transition is not only a change in the mix but also an increased access to modern energy, at cheaper energy unit price, making modern practices possible (improved heating, hot water for instance). The shortages and the bypassing of some neighborhoods by the gas network result in unequal access, which is felt as injustice, as clearly visible in the following quote from a young Cairene, without access to the gas network, complaining that his aunt, who enjoyed access to the gas network, spent less than four times what he spent on gas: “it is her luxury of washing the dishes with hot water and stay longer under a hot shower” (interview, march 2011).

Energy justice is then becoming a new claim induced by energy transition. This resulted in transforming the political agenda and the policy tools. The justification of the donors and government now integrate this concern for affordability (price and connection cost), as highlighted in this recent communiqué presenting the next stage of the World Bank funded project of gas in Egypt: “The project will provide financial support to finance the connection charges in disadvantaged areas so that poor households can also connect to the gas grid”, said Husam Mohamed Beides, the project's Task Team Leader (World Bank, 24/5/2014). This highlights the dynamic interplay of top-down measures and the people's appropriation of some of the goals of this policy.

The introduction of new policy tools, aiming at subsidizing not the gas per se but the connection cost, cannot be separated from the context of strong protests against the energy policy of the Egyptian government, as many newspapers articles have recently reported.[9] In this respect, it underscores two points about the construction and the broadening of an agenda of energy justice (Day and Walker, 2013: it is the result of a messy process, and it assembles elements of very different kinds, like a political revolution in Egypt, economic and financial mechanisms and the building of new mains in Egyptian cities.

The last point in this discussion underscores the links between the existing territorial formation, both in political and material terms, and the implementation and adjustments of the energy transition policy. In the above examples, we showed that the existing urban morphology of the city in Cairo or Sfax, curbed the universalization of gas networks. In Istanbul, practices of supplying free coal to citizens with the goal of securing votes for the incumbent municipality also contradict this policy. The territorial formation then slows or impedes the energy transition. Nevertheless, even partially implemented, this policy also has increased social gaps inside the metropolitan spaces, between places and people than have access and those who have not. These paradoxical trends highlight the mutually constitutive process of the material, social and geographical dimensions of the urban space and energy transition policies.

5. Conclusion and policy implications

The examination of the policy of switching to natural gas in Istanbul Cairo and Sfax brings several lessons about energy governance.

Firstly, the three cases analyzed indicate a trend that, in contrast to low carbon technologies, has been under researched in most current research into urban energy transitions, specifically in emerging cities: the development of natural gas networks in cities. It is quite likely that similar policies can be identified in

[8] Tunisie: les bouteilles de gaz n'arrivent pas aux régions du sud », *in Espace Manager.com*, November 25, 2011 ⟨http://www.espacemanager.com/divers/tunisie-les-bouteilles-de-gaz-n-arrivent-pas-aux-regions-du-sud.html⟩.

[9] For instance: “President Sisi urges support for government in face of electricity crisis”. *Egypt Independent*. September 7th, 2014. Available at: ⟨http://www.egyptindependent.com//news/president-sisi-urges-support-government-face-electricity-crisis⟩.

many other cities, particularly in places with natural gas resources: e.g., Algeria or Bolivia. Such policies deserve further attention from researchers not only because their results significantly transform the concerned cities and energy practices. They also impact the way we conceptualize energy transition and the way it is governed.

Two main justifications for implementing natural gas energy transition have been identified, with diverging territorial and governance implications:

- the first was the fight against air pollution, which took place in a wider metropolitan strategy of physical modernization, thus emphasizing the leading role of metropolitan authorities (Istanbul);
- the second aimed at cutting state expenditures by promoting locally available and less or not at all subsidized energy. Inspired by macro-political concerns, with little consideration for metropolitan issues, such a policy is led by the state and the utilities it controls.

In both cases, the lack of concern for climate change and greenhouse gas emissions is very clear. This contrasts with the ordinary presentation of low carbon energy transition where such goal is a major and prime objective. As a consequence, it involves that donors, international climate agencies and governments wishing to encourage energy transition in developing and emerging megacities also strongly focus on economic and metropolitan arguments in order to enroll more cities into energy transition schemes. This is currently not highlighted enough (for instance: OECD (2010), UN Habitat (2011)).

Concerns for energy justice, as revealed in the three case studies, have major consequences for governance. We do not only speak of the governance of the energy system but, as protests related to energy services observed before and more strongly since the Arab Spring have shown, of national stability itself. Access to modern energy forms has become a major stake, one that requires several policy moves:

- Utilities and their political authorities (metropolitan and national governments) must carefully design policy tools to fit the material constraints of popular housing and neighborhoods, and their financial possibilities. This involves classical safety nets and social tariffs but also incentives adapted to specific urban morphology.
- It is clear that such measures cannot by themselves remove all barriers. The universalization of energy transition programs, combining energy and environmental efficiency, social sustainability and access involves mixing energy sources and technologies. Therefore it is necessary to establish governance schemes that go beyond mono-energy approach (e.g. natural gas networks, solar water heaters, photovoltaic panels, insulation, as well as the more traditional LPG). We believe our geographical approach has particularly underscored that various energy forms already and will coexist together for long. The stake is to articulate them and to coordinate their promotion, in the metropolitan space as well as economically, to avoid competition and to ensure complementarity. In this respect, we suggest that much could be learned from the policy of universalizing water in poor metropolis, thanks to a diverse and gradual basket of instruments adapted to various publics and spaces, and through recognizing the existence of composite systems (Jaglin, 2013).

The issue of scale in energy governance is a last point this article has addressed. The case of Istanbul demonstrates the efficiency of an energy governance scheme led by a metropolitan actor, since energy measures are integrated and coordinated with many other aiming at modernizing the city, from physical planning to transportation – and this is not to say that everything works perfectly in this city. But the case of Istanbul might seem difficult to emulate because political and administrative organizations are specific to every city and country. However, it seems that in Tunisian cities and specifically in Sfax, as well as in Cairo (and other Egyptian cities), the national and regional utilities have to better take into consideration local issues and specificities while designing energy transition schemes. This seems difficult to achieve without local participation, decentralization and a democratic endeavor.

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